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*THE REVIVAL OF INORGANIC CHEMISTRY.**

NOTHING can be more instructive to the student interested in the results of intellectual cross-fertilization than the effect of the recent fecundation of chemistry by physics. Through the application of physical methods and ideas to chemistry, the latter has given birth to a new branch of study, physical chemistry, which promises to produce as radical a change in our conceptions of molecular phenomena as did the overthrow of the phlogiston theory or the introduction of the conception of valency at a later period.

The attempt of Berthollet to introduce dynamical conceptions into chemistry, at the beginning of the century, fell on thorny ground, and from that day until very recent years the growth of chemistry, great as it has been, has been most remarkably one-sided. The Periodic Law has been discovered, many new elements have been found, new compounds without number have been prepared, the rules governing their formations and transformations have been ascertained, and even their microscopic anatomy has been studied to such an extent that for countless of them we have established formulas which express, schematically, the relative arrangement of the atoms in the molecule. In stereochemistry we have even gone so far as to be able to

*Annual address of the President of the Chemical Society of Washington, delivered March 30, 1899.

indicate, in a rough way, the actual relations of the atoms in space; yet, with all this, a most important part of the problem has been almost neglected. To use a biological expression, chemistry has been enormously developed on the morphological, and but little on the physiological side. Chemists have concerned themselves greatly with the products of chemical reactions, and but little with the nature of the reactions themselves. The molecule has been treated as a dead, rigid body is treated by the anatomist, but its study as a living, moving mass, filled with energy and capable of reacting by virtue of this energy, has been largely left to the future. Even as late as 1882 the German physiologist Emil du Bois-Reymond used the words which have since been in the mouth of every physical chemist:

"In contradistinction to modern chemistry, we may call physical chemistry the *chemistry of the future*."

Since 1882, thanks to the labors and inspiring influence of Ostwald, van't Hoff, Arrhenius, Nernst and others, physical chemistry is no longer the chemistry of the future merely, but of the present, and apart from the quickening influence which it is exerting in nearly all branches of chemistry proper, both pure and applied, we are beginning to perceive that we are entering a period in which chemistry will be of greater service to the allied sciences. Geological chemistry is showing signs of reviving under the stimulus of physico-chemical conceptions, and we are finding, too, that as physiological chemistry is not merely the chemistry of sugar, or urea, or albumin, but preeminently a science of moving and changing molecules, it can only progress by the aid of a knowledge of the laws of chemical energy.

The achievements of physical chemistry form, perhaps, the most interesting phase of the recent history of our science, but its followers have spoken for themselves so often of late years, and have presented the subject so much better than I could do it, that I feel compelled to consider a perhaps humbler, but yet not unimportant, field of research, which, in a sense, may also be called a part of the chemistry of the future, the field of *Inorganic Chemistry*. The relations of physical and inorganic chemistry have recently been discussed by van't Hoff in his admirable address delivered last summer before the Society of German Scientists and Physicians, and I shall, therefore, limit myself to the consideration of a few points of a more strictly chemical nature, touching the relations of physical and inorganic chemistry only incidentally.

The aim of physical chemistry will have been accomplished when it has established a mathematical equation which, by proper substitution, will enable us to predict the nature of every possible chemical system or reaction, and the properties, physical and chemical, of every possible element or compound. Until he has reached this chemical millennium, unless he will risk falling into the pit which has received so many philosophers in the past, the chemist must continue to advance by the route by which our understanding of every other branch of physical science has been reached. Notwithstanding all that physical chemistry can do with this material at present in hand, the experimenter must long continue to take the short cut to knowledge and find out what his elements and compounds will do by first actually getting them in hand, by precipitation, filtration, distillation, crystallization and the like. It may be questioned whether our present knowledge of facts would ever suffice to enable us to predict, for example, a single atomic weight with accuracy, or to explain that wonderful relation between properties and atomic weights known as the Periodic Law. A few enthusiastic physical chemists have

spoken slightingly of the compound-maker, as a kind of inferior being, apparently forgetting that it is just this kind of pioneer work which has supplied the material for their labors, that the first requisite for successful generalization is the possession of a large number of pure substances, of accurately known composition and properties, many of which can only be obtained by work which is so elaborate and difficult, and which requires such concentration of effort that he who follows it can well be excused if he does not always look on the product of his labor as merely means to another end. It is tolerably clear that, for a long time to come, experimentizing must keep equal pace with mathematicizing, and if the former have been pushed so far in one direction as to appear to afford no prospect of continued progress we must not abandon it altogether, but consider whether it may not be still profitably pursued along other lines. Let us consider whether we must all turn mathematical chemists, or whether there is not much left to be done by those trained in the older school, working along old-fashioned lines and by old-fashioned methods.

Descriptive chemistry, as it exists to-day, is a science which has grown and is still growing enormously in a single direction, that of organic chemistry, the chemistry of the compounds of carbon. We are at present acquainted with about seventy-five chemical elements, which are found in the most varied proportion in those parts of the earth which are accessible to our observation, namely, the crust, the sea and the air. The accompanying table, calculated by Clarke, shows the relative abundance of the elements in a sphere comprising the crust for a depth of ten miles, the ocean and the atmosphere:

Oxygen	49.98
Silicon	25.30
Aluminium	7.26
Iron	5.08
Calcium	3.51
Magnesium	2.50
Sodium	2.28
Potassium	2.23
Hydrogen	.94
Titanium	.30
Carbon	.21
Chlorine, Bromine	.51
Phosphorus	.09
Manganese	.07
Sulphur	.04
Barium	.03
Nitrogen	.02
Chromium	.01

The nineteen elements here given make up nearly the whole mass; the remaining fifty-five or thereabouts, taken together, and making all possible allowance for error, do not amount to more than at most 1 per cent. Observe that the element *carbon* amounts to but one-fifth of 1 per cent. To be sure, this is no argument that the chemistry of carbon is relatively unimportant; on the contrary, there is no necessary connection between the abundance of an element and its ability to carry us further toward a knowledge of chemical laws. Nevertheless, to an intelligence not having its seat in a body largely made up of carbon compounds, it might appear somewhat surprising that chemists should have attempted to base a science on the investigation of an element which exists in such relatively insignificant amounts, the compounds of which, with but few exceptions, are incapable of formation at the freezing point of water, or of existence at the lowest red heat; and should have chosen to devote nearly all of their energy to its study.

Apart from the special subject of coal, petroleum and asphalt, carbon is of practical importance to the geologist only in the form of carbon dioxide and the carbonates, while of the chemical properties of silicon, which constitutes 27 per cent. of the earth's crust, and of the silicates, which make up nearly all of it, we know vastly less than of the

derivatives of the single carbon compound, *benzene*. A study of the chemical changes taking place in the sun, and of most of those occurring in the interior of the earth, might almost leave carbon out of account; it would certainly have no more importance than titanium, an element of which few but chemists have ever heard, but which is more abundant and as widely distributed.

Carbon, as an essential constituent of living beings, constantly forces itself on our attention, yet this is not to be considered as by any means the chief cause of the predominance of organic chemistry. Comparatively few of the best studied organic compounds have more than the remotest connection with the phenomena of life. Phosphorus and sulphur, to say nothing of oxygen, hydrogen and nitrogen, are quite as important in this respect as carbon, yet how relatively little do we know of phosphorus and sulphur in their chemical relations, or even of nitrogen. The extraordinary development of carbon chemistry is due mainly to reasons of a chemical nature, which, by rendering its compounds easier to study, have made progress in this direction a line of least resistance. This has not been without its advantages, for we have been led to discern laws which could not have been perceived so soon had the working forces been more evenly distributed, but it has also had the unfortunate result that the theories of molecular structure, derived wholly from the study of carbon compounds, have been applied to all classes of inorganic compounds too hastily and without sufficient research. The inorganic chemist has done little but make new compounds, and ascribe to them structural formulas seldom based on the results of experiment, but rather on the possibility of drawing schemes on paper, in which the various valences or bonds were mutually satisfied (how, did not matter much), while those substances which were inconsiderate enough to refuse to submit to this operation without violating every probable or possible assumption have been labeled 'molecular compounds,' and under this name submitted to a forced neglect, which soon resulted in their being forgotten. We shall presently see that an increasing respect for these so-called molecular compounds is one of the features of the revival of inorganic chemistry.

In the earlier days of chemistry no sharp line was drawn between inorganic and organic substances. It is generally thought that we owe this distinction to Nicholas Lémery, who, in 1675, classified substances, according to their origin, as mineral, vegetable and animal, a distinction which has survived until the present day in popular speech. Lavoisier, recognizing in substances of vegetable and animal origin the elements carbon, hydrogen, nitrogen and oxygen, and led by his researches to attribute a peculiar importance to oxygen, regarded inorganic bases and acids as oxides of simple radicals, and organic bodies as oxides of compound radicals composed of carbon, hydrogen and sometimes nitrogen, but did not otherwise distinguish them. Even in 1811 it was undetermined whether carbon compounds obey the laws of constant and multiple proportions, and it was two or three years more before Berzelius, having sufficiently improved the methods of organic analysis, definitely proved that they do, in fact, conform to these laws, but are of greater complexity than the comparatively simple inorganic compounds then known. In his electro-chemical theory, the theory of dualism, developed between 1812 and 1818, Berzelius regarded the simple inorganic bodies, such as the bases and acids, as binary compounds of positive with negative atoms, held together by electrical attraction; the more complex bodies, as the salts, being binary compounds of a higher order; the organic compounds, on the contrary, being

regarded as ternary or quaternary. Later he extended the dualistic conception to these also, adopting the idea of Lavoisier that they are binary compounds of oxygen with compound radicals, composed of carbon, hydrogen and sometimes nitrogen, a view which he developed further and never wholly abandoned. In 1817 we find Leopold Gmelin maintaining that organic compounds are the products of a vital force and cannot be produced artificially. This view was entertained by Berzelius even as late as 1827 or later. Berzelius attributed the formation of organic compounds, with their relatively weak positive and negative characters, to peculiar electrical conditions existing in the organism. We cannot reproduce these conditions in the laboratory, and, therefore, cannot produce organic compounds artificially. Those transformations which we are able to effect are always from the more complex to the simpler. We can isolate the intermediate stages in the breaking-down of organic matter into carbon dioxide, water and ammonia, that is, we can follow the change of matter from the organic to the inorganic, step by step, but we cannot reverse the process and build up, nor can we hope to do so in the future. This opinion of Berzelius marks the widest gulf between organic and inorganic chemistry, a gulf too wide for human power to bridge. How dangerous it is to set limits to the power of science! But one year later, in 1828, Wöhler announced his discovery that urea, a body of animal origin, could be produced from ammonium cyanate, a substance, which, in its turn, can be built up from its constituent elements, carbon, hydrogen, oxygen and nitrogen. This was the first of a series of innumerable syntheses which have fully disposed of the idea that any fundamental distinction exists between inorganic and organic compounds. Although we have not yet made albumin in the laboratory, we all expect that it will be done, and nearly every chemist now believes that even the properties of living protoplasm are due, not to any peculiar vital force inherent in the protoplasm itself, but to the special properties of the carbon, hydrogen, oxygen, nitrogen, phosphorus and other elements of which it is composed. My subject does not permit me to consider in detail how the idea of organic chemistry, as the chemistry of compound radicals, was evolved; how the radical theory was replaced by the conception of the molecule as a unit; how, in 1853, the theory of valency began to develop, and how this, with the type theory, the theory of the linkage of atoms, and the constant tetravalency of carbon, led, in the early sixties, to our present conceptions of the structure of organic molecules. With the advent of the fully developed structural formula, the brilliant progress of organic chemistry toward fuller theoretical development came to an end with remarkable suddenness. Kekulé's ingenious and fruitful theory of the benzene ring, suggested in 1865, was an application, to a particular class of compounds, of principles already established, but involved no fundamentally new conceptions. Organic chemistry entered upon what has aptly been termed a period of 'formula worship.' The establishment of the constitutional formula became the highest aim of the devotees of this cult, against which but few chemists, for example, Kolbe and Mendelejeff, have had the courage to protest. In pursuing this aim the organic chemists have unquestionably accumulated an enormous mass of valuable information and detail; have discovered new methods of synthesis, new laws of more or less special application and new compounds of practical value; but, with all their labors, the ordinary structural formula of to-day means no more than it did in 1865. In stereo-chemistry, however, the development of the structural formula in space of three dimensions, organic chem-

istry, has shown real progress, especially since 1887, when LeBel and van't Hoff's theory of the asymmetric carbon atom, which was proposed in 1874, but which slumbered almost forgotten, was revived by Wislicenus. At present the most important developments of structural chemistry, both organic and inorganic, unquestionably have the question of space relation as their basis.

The development of inorganic chemistry presents some marked distinctions from that of organic chemistry. Up to the year 1820 nearly all the important discoveries and generalizations came from the inorganic side. Richter's discovery of the law of equivalents; the researches of Scheele, Cavendish, Priestley; the development of the theory of oxidation by Lavoisier; the atomic hypothesis of Dalton and his laws of constant and multiple proportions, and the placing of them on a firm foundation by the remarkable labors of Berzelius; Gay Lussac's law of the simple relation of the volumes of reacting gases; Dulong and Petit's law, and the law of isomorphism, all fall within this period and antedate the beginning of the rapid development of carbon chemistry. The same is true of the discovery of the alkali metals, the recognition of the elementary nature of chlorine, and of the establishment of the existence of hydrogen acids, and many other important facts. In these the study of carbon played a relatively insignificant part. The electro-chemical theory of Berzelius, too, which was of such great importance as a working hypothesis, was of inorganic origin. By 1830 the predominance of organic chemistry was already pronounced, and with the increased attention given to this new field the interest in inorganic chemistry lagged behind. All, or nearly all, the developments of theoretical importance began to come from the inorganic side. The history of chemistry from 1830 to 1865 is practically the history of organic chemistry. I do not mean that research was confined merely to carbon compounds. The influence of Berzelius continued to be felt, and men like Heinrich Rose, Wöhler, Bunsen and many others made valuable contributions to inorganic chemistry, as well as several like Dumas, Liebig and others, whose reputation rests chiefly on their organic work. The great inorganic chemists were mostly men of an analytical rather than synthetical turn of mind. The growth of mineralogy led to the discovery of new elements, and the analytical requirements to which it, as well as practical chemistry, gave rise conduced largely to the study of inorganic compounds. The conception of valency, while due mainly to organic chemistry, owes not a little to inorganic chemistry, though it did but little to further it. Numerous atomic weight determinations of greater or less accuracy were made, sometimes with a purely analytic purpose, sometimes with the object of testing the validity of Prout's hypothesis, but these exercised but little influence on the theoretical growth of inorganic chemistry, which remained for the most part a mass of unconnected facts.

In considering the causes to which is due the preeminent attention given to organic chemistry since 1830, the point most to be emphasized is that at no time since that date has there been lacking a well-defined working hypothesis of the nature of organic compounds. Not only did these substances prove eminently susceptible of classification into types, but, for reasons to be stated later, the transformations discovered were so numerous, and the possibilities of producing synthetically old or new compounds, and of working out new theories, were so attractive that most of the best chemical minds between 1830 and 1865, or even later, were drawn into organic chemistry. Another important factor is that of inertia. Most students of nature do not willingly

enter upon entirely new fields of research. The pupils of the great masters of organic chemistry, Liebig, Dumas, Hofmann, Wurtz, Kolbe, Kekulé and others, found enough to do in following in the footsteps of their teachers, and were little inclined to seek new pastures. The requirements of candidates for the doctorate, whereby the experimental material for the dissertation had to be accumulated in a comparatively short time, led to the assignment of topics with which the instructor was familiar, and which were fairly sure of giving positive results within a year or two, and, as we all know, no branch of chemistry yields results so readily as the study of carbon compounds, with its highly developed synthetical methods. As the *Chemiker-Zeitung* has recently pointed out, even at the present day the full professorships in German universities are almost invariably held by organic chemists, while inorganic chemistry is left to subordinates. The weight of authority and influence being on the side of organic chemistry, the student who looks forward to a university career sees that his chances of promotion are better if he follow the organic rather than the inorganic direction. I need hardly add that the more mercenary hope of obtaining a new dye-stuff or a new remedy, or of replacing nature in making an alkaloid, has also been a powerful incentive to many.

Let us now consider some of the reasons which have their root in the chemical peculiarities of carbon, and which render its compounds, at least those which are not too complex, comparatively easy to study. These conditions are not peculiar to carbon, but no other element, as far as is known, presents as many of them at the same time.

1. Carbon compounds being very generally soluble in neutral solvents, frequently crystalline, and often volatile without decomposition at comparatively low temperatures, are peculiarly adapted to separation in a state of purity by fractional crystallization or distillation, and for the same reason it is usually possible to determine their true molecular weights. The very general possession of melting or boiling points lying within easily observable ranges of temperature greatly facilitates identification.

2. The power of carbon of uniting, atom to atom, to form chains, the form and size of which can be easily regulated by known synthetic methods, and the stability of which is sufficient to allow of manipulation under easily attainable conditions, is a marked peculiarity of this element. This, with the power of forming stable compounds with hydrogen, is the basis of the definition of organic chemistry as 'the chemistry of the hydrocarbons and their derivatives.' With regard to self-linking power the other elements are in marked contrast. We know with certainty no compounds in which two atoms of boron are linked, not more than four nitrogen atoms have been arranged tandem, while of silicon, the nearest relative of carbon, we know at best a half-dozen well-defined compounds with two atoms of this element in series, and but one with three; analogues of the hydrocarbons are unknown, with the exception of silico-methane, and the instability of this is sufficient proof that a series of silicon paraffines would be most difficult to prepare, and the same would apply to all classes of silicon compounds in which self-linking is a prerequisite. It does not appear probable that we shall ever have a very extensive chemistry of the 'hydrosilicons and their derivatives.' Among the compounds of other elements self-linkage occurs in but few cases and is limited in extent.

3. It is a highly important property of carbon compounds that their molecules tend to preserve their individuality; they generally do not, though there are exceptions, *spontaneously* avail themselves of opportuni-

ties for condensation, whether by polymerization or by union of two or more molecules with separation of water or ammonia. The so-called double and triple union between carbon atoms only exceptionally leads to spontaneous polymerization, while with silicon this latter is apparently the rule. The important carbonyl group, C = O, the characteristic group of organic acids, aldehydes and ketones, shows but little tendency to polymerize, while organic hydroxyl compounds are usually stable and do not spontaneously give rise to ethers or acid anhydrides. The silicon analogue of carbonyl, Si = O, on the contrary, appears to polymerize with great ease. The ethers of carbonic acid are well known, but the metasilicic ethers, those of the type $SiO(OR)_2$, appear to exist only as polymers. The silicic acids, too, show a marked tendency to condense by dehydration and pass spontaneously into complex bodies. It is easy to see what would have been the result if carbon behaved like silicon. Instead of the innumerable sharply defined organic acids, aldehydes, ketones and alcohols, each produced by a definite synthetic process, each reaction would give rise to an almost inextricable mixture of condensation products, carbon dioxide would be a solid like silica, and organic chemistry would be scarcely further advanced than is the chemistry of silicon. This tendency of carbon compounds to simplicity in reaction, each molecule acting as if it were alone present, has been, therefore, an important factor in facilitating the growth of organic chemistry.

4. Another feature of carbon, which plays an important part, is the ease with which intermediate or transition products can be formed. It is much easier to limit reactions in the case of carbon compounds than in others. Compare, for example, the action of chlorine on CH_4 and SiH_4.

5. The tendency to dissociation, both hydrolytic and electrolytic, is in general less marked among carbon compounds, whence it is easier to control the course of a reaction and to exclude changes of a spontaneous nature. Finally, the carbon compounds show but little tendency to the formation of so-called molecular addition products, of which the metal ammonias, the double salts and the compounds with water of crystallization are examples, the rational interpretation of which is difficult.

A full consideration of the peculiarities of carbon which have facilitated the synthesis of such vast numbers of organic compounds would be beyond the scope of this address. The above are the most important, and their relative absence in the majority of elements explains largely the backward state of our knowledge of them. Our inability to determine the true molecular weight of insoluble and non-volatile substances; the difficulty of limiting reactions so as to obtain intermediate products; of preventing condensations; of separating mixtures and identifying their constituents by such simple methods as melting- and boiling-point determinations; of building up step by step; of dissecting atom by atom; of explaining molecular compounds—these are hindrances which can only be overcome by greater perfection of our experimental methods, and which often render the study of the constitution of inorganic bodies a problem of great difficulty, even in the case of many of the simplest.

At the very time that the organic structural formula was beginning to turn the attention of organic chemists away from a further development of theory to a greater elaboration of details the Englishman Newlands was publishing papers which contained the germ of the Periodic Law. In 1865 Kekulé announced his theory of the benzene ring; in 1864 Newlands showed that if the elements be arranged in the order of their atomic weights 'the eighth element, starting from a given one, is a kind

of repetition of the first, like the eighth note of an octave in music.' This discovery of Newlands of a fact which later developed into the Periodic Law does not, however, mark the beginning of a new direction in chemical thought. It marks rather that point in a long series of speculations at which chemists were beginning to grasp an idea after which they had been groping blindly for many years, the conception that the elements are not wholly unrelated bodies, but that there is some definite law connecting their properties with their atomic weights. Beginning in 1815, with the claim of Prout that the atomic weights of the elements are multiples of that of hydrogen, which led him to suggest that hydrogen is the primitive element from which the others are built up, we find numerous speculations, some devoted merely to finding arithmetical relations among the atomic weights, such as the law of triads, others attempting to show how the elements could be built up from one or more primitive constituents. Most of these did not lead to any marked advance of chemical theory, but Prout's hypothesis found very able defenders and greatly encouraged accurate atomic-weight determinations. The labors of Dumas, Marignac and especially of Stas, in this field, are directly due to the desire to test the validity of Prout's suggestion. Up to 1860 not only were the atomic weights uncertain to within a few decimals, but, for other reasons, even the relative position of the elements in an ascending series was often uncertain; our present empirical formulas had not been fully established; it was uncertain, for instance, whether water was HO with $0 = 8$ or H_2O with $0 = 16$, or whether silica was SiO_2 with $Si = 28$ or SiO_3 with $Si = 21$. So when Gladstone, in 1853, arranged the elements in the order of ascending atomic weights he failed to perceive any noteworthy relation. Nine years later the French engineer and geologist de Chancourtois, using the newer and now adopted atomic weights, arranged the elements in a spiral or helical form around a cylinder, in ascending order, and was led to the conclusion that the 'properities of bodies are properties of the numbers,' a vague statement of the now familiar phase that the properties of the elements are functions of their atomic weights. As already mentioned, he was followed closely by Newlands, whose work, however, met with but slight recognition. Time is wanting to show how in the period 1864–1869 the Periodic Law was developed by the labors of Newlands, and more especially of Lothar Meyer and Mendelejeff, working independently. It affords an interesting example of how a great idea is developed about the same time in the minds of several men working independently and unknown to each other. In 1871 Mendelejeff published a table which shows the periodic law essentially as we find it to-day, the only changes consisting in the addition of a few newly discovered elements and in placing a few of the older elements in their proper positions, as a result of more accurate atomic-weight determinations.

The period 1863–1870 was, therefore, of the greatest importance for inorganic chemistry, as it saw the development of the idea that the properties of the elements are *periodic* functions of their atomic weights. The time which has since elapsed has been even more fruitful than any previous period in speculations, having for their object the finding of mathematical relations between the atomic weights and in theories of the evolution of matter from one or two primal constituents. Many modifications of the periodic scheme have been devised, but they present but few or no advantages over the simple arrangement of Mendelejeff and Lothar Meyer. The great fact still remains, unmodified and unimproved, that if the ele-

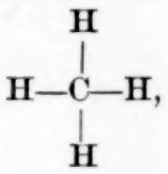
ments be arranged in the order of increasing atomic weights there is a recurrence of the properties of elements lower in the scale—in short, that these properties are periodic functions of the atomic weights.

The discovery of the new group of inert gases, helium, neon, argon and xenon, with perhaps krypton and metargon, has not modified our idea of the Periodic Law essentially. They appear to fit well into the system, and it is now only remarkable that their existence was not surmised by Mendelejeff, who so successfully predicted several then-unknown elements. Although the periodic system is, even to-day, the object of attack by a few chemists, who appear to be blinded by its unquestioned defects to the obvious truths which it expresses, it may be safely said that the great central fact of the periodicity in the properties of the elements is just as firmly established as the law of gravitation,and that, whatever modifications may have to be made in the scheme as a whole, this central fact will never be done away with. The atomic theory may be supplanted by something better, but its successor will equally have to take account of the stoichiometrical relations of the elements, which are ba-ed not on theory, but on observation pure and simple, and it is on these, and not on the atomic theory, that the Periodic Law is based.

The Periodic Law is exerting a stimulating influence on inorganic chemistry in various ways. It is leading to a more careful study of all the elements, with the object of discovering further analogies; new compounds are being prepared and old ones studied better with this in view; new kinds of periodicity are being sought for in physical as well as in chemical properties. The question of the nature of the rare earth metals, the asteroids of the elementary system, as Crookes calls them, is being attacked with greater energy. Are these, of which Crookes claims there are thirty or perhaps sixty, capable of being fitted into the system, as it now exists? Must we modify it in order to take them in, or do they represent certain exceptional phases of the evolution of matter from the original protyl, or different very stable modifications or allotropic forms of a few elements? Do the blanks within the system represent existing but as yet undiscovered elements? Do some of them correspond to hypothetical elements which for some unknown reason are incapable of existence, like many organic compounds which are theoretically possible, but which, if momentarily existing, lapse at once into other forms, or must the scheme be so modified as to exclude them? These are some of the questions raised by the Periodic Law which it belongs to the inorganic chemist to solve. Most important of all is the question of the *cause* of the periodicity. Before we can hope to establish a mathematical and possibly a genetic relation between a series of numbers, such as the atomic weights and the chemical properties of the elements, we must establish with greater accuracy than heretofore the precise magnitude of these numbers, and it is this that an ever increasing number of atomic-weight chemists is striving to do. The question of the unity of matter is one to a solution of which we are no nearer than ever, and the Periodic Law, in its present form, does not afford a proof or, I think, even a presumption in favor of a genetic relation between the elements. It is quite conceivable that we may have relations of properties without a common origin. With ever increasing accuracy, we seem to be removing further and further from the possibility of any hypothesis like that of Prout. The electric furnace, with its temperature of 3,500° C., gives not a sign of the decomposition or transformation of the elements. These questions and the query why we know no elements below hydrogen or above uranium, why the num-

ber of the elements is limited, and why there are not as many kinds of matter as there are different wave-lengths of light—all these seem to belong as yet to a scientific dreamland rather than to the realm of legitimate research, yet their solution, if possible at all, will be accomplished only by the labors of the inorganic chemist.

Let us now turn to the more special consideration of the questions of the constitutional formulas of inorganic compounds. The more conservative organic chemists have always been careful to state that the so-called structural formulas are *reaction formulas* merely, that is, that they are not intended to express the actual relations of the atoms in the molecule, but are merely convenient schemes for rendering possible reactions visible to the eye. Probably most chemists regard them as more than this, as actual diagrammatic representations of the way in which the atoms are combined. The formula of marsh gas, for example,



is regarded as more than a visualizing of its chemical properties; it implies that the carbon atom is an actual physical link between the hydrogen atoms, which are combined directly with the carbon but not with each other. Stereochemical formulas are confessedly more than reaction formulas, and the steric conception of the so-called double and triple union asserts that these actually exist in the sense the words imply, and are not merely names for unknown conditions.

Many of the simpler organic structural formulas unquestionably have an enormous mass of evidence in their favor, but many others we must be on our guard against taking too seriously, and must for the present regard as nothing more than reaction formulas. That we can regard any of them as well established is due, more than to anything else, to the almost invariably constant tetravalency of the carbon atom. Unfortunately, the valency of many of the elements entering into the composition of inorganic compounds appears to be extremely variable and uncertain, and this has greatly impeded the study of the structure of these bodies. The inorganic chemist has been far too prone to assume that the structural theories of the organic chemist are of universal applicability, and, having once for all attributed a certain valency to an element, has been often content with devising structural formulas which have no better claim to recognition than that all the so-assumed bonds are 'satisfied.' At other times a particular valency has been assumed for no other reason than that it enabled him to contrive a formula for the special case under consideration. The books treating of such matters frequently exhibit wonderfully ingenious inorganic structural formulas which are wholly devoid of a reasonable amount of experimental evidence and which are, therefore, often nothing but pure rubbish. With many inorganic chemists, formula worship has degenerated into fetishism. Let us consider a few examples. For nitric acid, one of the simplest and most familiar inorganic compounds, several constitutional formulas may be written, in which the hydrogen is directly united to the nitrogen or separated from it by one or two oxygen atoms, and in which nitrogen may be either tri- or pentavalent. Some of these are given in the books as if they were gospel truth. Brühl, who has investigated the question by physical methods, suggests that the hydrogen atom is not directly united to any part of the NO_3 radical, but is rotating around it and possibly combined with each oxygen atom in succession, a view approaching that of Werner. There are at least five formulas

proposed for this simple acid. For the familiar potassium chloroplatinate, K_2PtCl_6, there are four constitutional formulas seriously advocated at present. It may be $K_2 = PtCl_6$, with octavalent platinum;

$$\left.\begin{matrix} KCl = Cl \\ KCl = Cl \end{matrix}\right\rangle PtCl_2,$$

with tetravalent platinum and trivalent chlorine, as required by Remsen's theory; $(PtCl_6)K_2$ in the sense of Werner's theory, the two potassium atoms being combined with the $PtCl_6$ as a whole, or it may be a molecular compound in which two molecules KCl as wholes combine with $PtCl_4$ as a whole. The formulas suggested for most minerals are pure guess work. The silicates are usually written as if containing the group $Si = O$, by analogy with carbonyl, $C = O$, yet there is not a single silicate in which this assumption rests on any experimental evidence, and the little we do actually know of the chemical behavior of silicon speaks against it. Such formulas, if not purely speculative and devoid of all basis and all value, as they frequently are, at best do not represent structure in the sense that the best established organic formulas do; they are at most reaction formulas only, or they represent partial molecules, in the same way that CH may stand for benzene (C_6H_6) or HPO_3 for a metaphosphoric acid. The attempt to interpret the double salts and halides, the compounds with water of crystallization or hydration, the metal-ammonias, the peculiar compounds of the zeolites described by Friedel, and other so-called molecular compounds, in the sense of the valence hypothesis, seems almost hopeless without taking such liberties with it as to render it nearly useless, and without making assumptions of very narrow and limited applicability. One may well question whether this hypothesis must not be very considerably qualified before it can be taken as the basis of a general theory of the structure of inorganic compounds.

One of the most striking indications of a revival of inorganic chemistry is the recent attempt of Werner to break away from the bonds of the organic-structure theory as applied to inorganic compounds and to establish a more general theory in which valency plays a comparatively insignificant rôle. The arguments on which Werner's hypothesis is founded are too numerous and elaborate to be presented here. Suffice it to say that it was primarily based on that peculiar class of bodies known as the metal-ammonias, consisting of metallic salts, combined with usually six or four molecules of ammonia, and in which the ammonia may be wholly or in part replaced by pyridine, water, acid radicals and other groups. These groups are supposed to be arranged symmetrically about the metallic atom, forming a radical, which, according to its nature, can combine *as a whole* with metals, halogens or other positive or negative groups. Thus, in the compound $CO(NH_3)_6Cl_3$, cobalt forms with NH_3 a radical, which combines as a whole with the three chlorine atoms; in $(PtCl_6)K_2$ the two potassium atoms are combined with the whole group $PtCl_6$ and not attached to any one part of it; the same applies to $(NH_4)Cl$, and to $K_2(SO_4)$ and $K_4(FeCN)_6$. In the formation of these radicals the bivalent NH_3, the neutral H_2O and the univalent Cl can replace each other indiscriminately; the valence theory is, therefore, practically thrown overboard entirely and in place of combination by bonds we have an extension of the old theory of molecular compounds applicable alike to the metal-ammonias, the ordinary oxygen salts, the double halides and the compounds with water of crystallization. It is yet too soon to predict the future of this hypothesis, which has already won numerous active adherents. It is scarcely too much to hope

that it will lead, perhaps with some modifications and extensions, to a more comprehensive theory of structure, and to a clearer definition of the as yet only vague conception of valency. It is the broadest generalization of inorganic chemistry since the discovery of the Periodic Law, and shows that inorganic chemists are no longer willing to be mere imitators and to close their eyes to the existence of whole groups of bodies which do not tally with current theories, and are beginning to see that in these is to be sought the key to a broader inorganic chemistry.

The slow development of inorganic chemistry during the period from 1830 to 1865, as compared with that of organic chemistry, was due, as has been seen, in part to the greater breadth and greater diversity of the field, to the relative absence of leading ideas and leading motives, and to the comparative tractability of carbon compounds as compared with inorganic compounds under the restrictions of the experimental methods in vogue. Prout's hypothesis and allied speculations gave a working hypothesis for a limited number of investigators, but the uncertainty of the atomic weights, which in part was conditioned by the imperfection of analytical methods, prevented any satisfactory results being reached. Absolute purity of materials and absolute accuracy of analytical methods are not of the first importance to the organic chemist, to whom errors of one or two points in the first decimal are seldom of any significance. To the atomic-weight chemist, on the contrary, accuracy is the very first point to be considered; not only must his material be absolutely free from impurities, but his methods must be beyond criticism, and it is only with the increasing perfection of analytical methods, admitting not only of quantitative determinations of the greatest accuracy, but also of the detection of traces of impurities which for ordinary purposes are negligible, that this kind of work has offered inducements to a large number of workers. The long-wanting, leading idea or motive has been in large part furnished by the Periodic Law. The comparison of the chemical and physical properties of the elements and their compounds, the search for new elements, the fuller investigation of those already known, with the view of more firmly establishing their place in the system, and the redetermination of the atomic weights, are evidence of its influence. Witness, for example, the great activity in the subject of the rare earths, the work on the relative position of nickel and cobalt in the system, and the investigations of the atomic weight of tellurium, having for their object the decision of the question whether this element actually has an atomic weight greater than that of iodine, as the best determinations thus far seem to indicate, or whether it is less, as its chemical analogy to sulphur and selenium requires.

Organic chemistry, with its limited range of temperature, is essentially a chemistry of the beaker, the Liebig condenser and the bomb oven; it demands but comparatively simple and cheap apparatus of glass, not calculated to withstand high temperatures, and as such is within the means of the humblest laboratory. The reverence of the organic chemist for the platinum crucible is something astounding. With improvements in apparatus for producing and materials for resisting high temperatures, new vistas have opened to the inorganic chemist, while the province of the organic chemist, limited as it is by the instability of his compounds, has derived no benefit therefrom. Not only do we owe to this the beautiful investigations of Victor Meyer and others on high-temperature vapor densities, but with the recent development of electrical technology the electric furnace has appeared, and with it a new chemistry, the chemistry of a temperature of 3,500° C. Not only have new

compounds been made which cannot be produced at lower temperatures, but the accessibility of many elements and compounds has been greatly increased. The reductions which Wöhler and Deville effected gram-wise in glass and porcelain tubes can now be carried out in the electric furnace pound-wise and even ton-wise. The manipulation of the current for electrolytic purposes, rendered possible by increased knowledge of the laws of electricity, as well as by ease of its production, is yielding results chiefly in the domain of inorganic chemistry, while the organic chemist is but tardily utilizing the current as a means of oxidation and reduction. Besides the extraordinary development of electro-metallurgy, the preparation of soda and chlorates and other technical processes, the application of electricity to purposes of analysis and for the synthesis of new compounds, such as the rare metal alums, percarbonic and persulphuric acids, and the isolation of fluorine, may be mentioned.

Passing to the opposite extreme of temperature, we find the development of high-temperature chemistry accompanied by the growth of a chemistry of low temperatures. The very recent improvements in the art of producing cold have made liquid air a cheap material, and with its aid Ramsay has been able to fractionally distil liquefied argon and to separate from it the contaminating elements of the same group, neon and xenon, as well as krypton and met-argon.

The part played by the spectroscope in chemistry is more or less familiar to everyone. From the further development of the science of spectroscopy it is clear that inorganic chemistry has much to gain. Whether or not the view first suggested by Clarke and long defended by Lockyer be true, that the elements undergo partial decomposition in the stars and nebulæ, it is upon this instrument that we must rely for our knowledge of the high-temperature chemistry of these bodies, a chemistry which is wholly inorganic.

The rapid growth of these sciences into which chemistry enters is producing an ever increasing demand upon the chemist for new researches. While the biologist must rely mainly on the organic chemist for his chemical data, no less must the mineralogist and geologist appeal to the inorganic chemist for the solution of many problems in their field. The formation and decomposition of minerals, the disintegration of rocks, the behavior of rock magmas, the phenomena of metamorphism, of ore deposition and vein formation, the influence of high temperatures and pressures—all these afford problems the solution of which is hopeless without the assistance of inorganic chemistry either alone or aided by physical chemistry. The chemist who has to meet the inquiries of the geologist, and who must too often confess our ignorance of the causes of even the simplest phenomena, can not help feeling what a splendid field is here open, awaiting only the advent of workers suitably trained and of laboratories properly equipped for research in chemical geology. The demands of the geologists are unquestionably destined to be among the most potent factors in the revival of inorganic chemistry.

It is not to be expected, nor is it to be desired, that inorganic chemistry will at once sweep organic chemistry from its position of preëminence. The causes to which this is due may outlast our generation, but that the inorganic tide is rising, and that this branch will finally attain its due position, can not be doubted. The recent establishment of a *Zeitschrift für anorganische Chemie*, while it may be deplored as increasing the already too great number of chemical journals, and as tending to widen rather than diminish the gap between the organic and inorganic branches,

is helping to produce a feeling of solidarity among inorganic chemists which never existed hitherto. Even in Germany, the stronghold of organic chemistry, the address of van't Hoff is exciting wide interest, and the *Chemiker Zeitung*, in urging the establishment of independent chairs and laboratories of inorganic chemistry, is advocating what will in time unquestionably be realized.

Inorganic chemistry is fortunate in that its renaissance is coming about at a time when physical methods are in vogue. The prediction of Du Bois-Reymond is being realized ; with the aid of physics it is attaining an insight into the dynamical aspect of the science which it could never have reached unassisted. But it is not alone by supplying new methods and suggesting new points of view that physics is aiding the revival of inorganic chemistry. Perhaps equally important is the fact that the rising school of physical chemists, unhampered by the traditions and limitations of organic chemistry, is finding it necessary to explore the whole range of the science in search of material for its investigations. The physical chemist is neither organic nor inorganic, or rather he is either, according to his requirements, but it is precisely because the inorganic field is wider and less developed than the organic that his demands are more likely to be productive of activity.

Energetics is now the basis of chemistry, and it is to be expected, therefore, that inorganic chemistry will not, in the future, have to pass through a period of arrested development and formula worship, such as have so long affected organic chemistry. There will always be compound makers, but their aim will be, not the establishment of constitutional formulas alone, but the study of the laws of chemical energy and the solution of the problem of the nature of matter. We may expect, too, that the still sharp line of demarcation between inorganic and organic chemistry and between dead and living matter will disappear. The inorganic chemist may not affect the synthesis of a proteid, but he will be able, with his wider knowledge, to contribute more to the solution of the problem of the nature of life than any amount of structurizing and synthesizing alone can do. To comprehend life we must understand carbon, but we can no more fully comprehend carbon without an understanding of the other elements than we can explain the earth without a knowledge of the other planets, or man without a knowledge of the fish. He, then, who pursues inorganic chemistry is not only contributing to a higher development of our science than can be reached by the study of carbon compounds alone, but is perhaps doing as much as the organic chemist toward realizing one of the greatest aims of research, the comprehension of life and its explanation in terms of physical science.

WASHINGTON, D. C. H. N. STOKES.

ON THE TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

THE next total solar eclipse will be visible as such in places both east and west of the Atlantic Ocean, and it is a matter of some thought to determine where it shall be observed. I have proposed to report to the governing board of Williams College that it is practicable to observe it on both sides at points to be fully determined later, as at present there is rather more than a year's time to make the needful arrangements.

The two countries where it shall be observed seem to be Portugal and our own Southern States, in the neighborhood of Coimbra and that of Norfolk, in Virginia, or perhaps farther south. The only doubt is the more or less uncertainty of weather. That, however, cannot be avoided, as the meteorologists are not yet able to predict with much certainty or at all for more

than a few days at a time. The Weather Bureaus at Washington and Lisbon will, of course, do all that they can, but the most that can now be done is to observe the weather in 1899, in the hope of getting some new light on the matter.

So far as the eclipse is concerned, which will certainly take place at the predicted time, it is possible and practicable to make calculations from the data in our American Ephemeris, and to do this within a few days, and in the coming months to make all needful preparations of instruments and training of observers, and with abundant spare time left.

I shall report to our trustees that the main effort to be made then will be towards photographing the eclipse as well and completely at both points as the time, short enough at best, will allow.

At Norfolk, in Virginia, and Ovár, in Portugal, the eclipse will be total long enough to be well photographed by instruments costing but little more than a hundred dollars for each station, instruments which can be made useful in several directions and can be readily placed at either station. The advantage of making the effort to observe at both places will be, of course, not that of making observations at the same time, but that of following out a uniform set of rules both in America and in Europe.

These rules can be readily formulated and practiced beforehand with comparatively little trouble, provided the astronomers can come to an agreement, which I think will be an easy matter.

The process of taking the photographs is so easy now that no difficulty will arise from this, and it will also be easy to train intelligent students into the necessary physical manipulations, with the help, at least, of the necessary photographers, who, I presume, will be readily brought to either station.

As the object of the present paper is merely to indicate what is to be done, I shall defer to another occasion any further details. In this, as in many other problems of practical astronomy, the main requirement is merely to indicate in common language the problems to be solved, and it will be sufficient to leave further consideration of the matter to another occasion.

Truman Henry Safford.

RECEPTION AND EXHIBITION OF THE NEW YORK ACADEMY OF SCIENCES.

The Annual Reception and Exhibition of the New York Academy of Sciences has come to be one of the most interesting social events of the scientific circles of the city. This fine spring weather and a beautifully suitable hall combined with the zeal of the exhibitors to furnish instructive entertainment to about three thousand persons. The reception was held, as usual, at the American Museum of Natural History, the first evening being reserved for members, exhibitors and special friends, and some 500 availed themselves of this opportunity to become better acquainted with their fellow members, and to see and discuss the advances in branches of science other than their own. Indeed, the justification and benefits of these exhibitions are to be sought quite as much in their broadening influence upon the point of view of specialists as in their possibilities for the layman and amateur.

The Museum authorities are exemplary in their hospitality, and the relations between this gigantic object lesson in science and the Academy are yearly growing more cordial. This year it was possible to hold the reception in the new hall of American Anthropology, west of the entrance on the main floor. The room is finished, but is not yet occupied by cases and permanent fixtures. A more suitable and appropriate location for a scientific reception it would be hard to imagine.

The General Committee in charge of the various sections were as follows :

Anatomy: Jos. S. Plake.
Astronomy: J. K. Rees.
Botany: C. C. Curtis.
Chemistry: Charles A. Doremus.
Electricity: Geo. F. Sever.
Ethnology and Archæology: L. Farrand.
Experimental Psychology: Chas. H. Judd.
Geology and Geography: J. F. Kemp and R. H. Cornish.
Mineralogy: A. J. Moses.
Paleontology: Gilbert van Ingen.
Photography: Cornelius Van Brunt.
Physics: C. C. Trowbridge.
Zoology: Gary N. Calkins.

While the display was not marked by any one prominent object, such as X-rays, still it was characterized by an excellent average of exhibits of sterling value, and should give its visitors an illustration of scientific interest as distinct from the spectacular.

It would, of course, be too prolix to attempt to give anything more than a few of the typical objects enumerated in the catalogue of some twenty pages.

The exhibit in Anatomy, though small in space, contained examples of most interesting points. The variations in the vermiform appendix, in the hepatic artery, etc.

The Harvard, Lick and Yerkes Observatories joined with that of Columbia in making the department of astronomy thoroughly representative of the recent interesting advances in that subject. Saturn's new moon, the new planet Eros, the rotation of the sun as shown in the Johns Hopkins spectra, the variation of latitude, vied with one another for popular favor.

The Bronx Park Botanical Garden contributed much interesting material to the Section of Botany, which contained some twenty titles.

In Chemistry popular interest seemed about equally divided between Munroe's illustrations of the effects of dynamite, smokeless powder and phenyldimethylpyrazolonesulphonates.

Ethnology showed Eskimo property marks, British Columbia baskets, a new hieroglyphic writing from Mexico, and other objects of almost equal interest.

Photometry, illusions, binocular rivalry, accuracy of movement and endurance were the objects of measurements in psychology.

Under Geology and Geography were shown recent work of the U. S. Geological Survey, the Maryland and the New York State Surveys, including the Geologic model of the Yellowstone National Park made by the U. S. Geological Survey to go to the Paris Exposition, and a relief map of the Adirondack Region made by Merrill. A suite of crude petroleums and several others of interesting rocks, together with large thin sections (three inches square) of rocks, furnished interesting material for the geologist and petrographer.

Mineralogy made a bewildering display of beautiful and interesting minerals and apparatus, with examples of photo-micrographs and photographs with uranium rays.

Physics presented grating spectra from Johns Hopkins, illustrating rotation of sun, effect of pressure upon the arc spectra, Zeeman effect and coincidence of metallic and Fraunhofer lines, special colorimeters, distillation apparatus, Crookes tubes, abbreviated continuous mercury vacuum pumps, a special arc light and audimeter, the effect of an alternating magnetic field upon a lamp filament, line screens for color photography, a complete set of apparatus for research in Hertz waves and wireless telegraphy, a low resistance and a standard-comparison Wheatstone bridge, apparatus used in measuring specific heat and temperature at mines 200 degrees Centigrade, also the new Dudley strematograph with results of its use in measuring stresses in railroad rails under moving trains.

Among many interesting exhibits in Pale-

ontology the magnificent limbs of four monstrous dinosaurs commanded special attention.

Similarly in Zoology the beautiful new case illustrating the nesting habits of the brown pelican rather out ran in popular favor other objects of great scientific interest.

As may be inferred even from the above brief and unsatisfactory sketch, the exhibition was as wide in its scope as it was scientifically interesting in its details. It must have been seen to be appreciated, and the thanks of those who did see it are due to the zeal of the exhibitors, especially those out of town, among whom should be mentioned Princeton, Harvard, Johns Hopkins and Chicago Universities, Lick and Yerkes Observatories, the United States, Maryland and New York Surveys.

William Hallock,
Chairman of Committee.

SCIENTIFIC BOOKS.

Lectures on the Evolution of Plants. By Douglas Houghton Campbell, Ph.D., Professor of Botany in the Leland Stanford Junior University. New York, The Macmillan Company. 1899. 12mo. Pp. viii + 319.

Professor Campbell is probably the foremost of the small group of what may be termed the philosophical botanists in America, and he is, no doubt, better prepared to discuss the questions taken up in this book, at least in so far as they deal with the archegoniates and seed plants, than any other of our students of plants. Some years ago he brought out his book 'The Structure and Development of the Mosses and Ferns,' in which he treated the subject in such a modern way as to give new meaning to what had to too great a degree been mere dry detail. In no uncertain words he traced the genetic relationship of group to group, and the student following him was made to feel that the fact of relationship was real and necessary, and not doubtful or shadowy.

In the little book before us the author discusses, in succession, the conditions of plant life, the simplest forms of life, algæ, fungi, mosses and liverworts, ferns, horsetails and club-mosses, gymnosperms, monocotyledons, dicotyledons, geological and geographical distribution, animals and plants, influence of environment, and at the end brings together his results in a chapter entitled 'summary and conclusions.'

We can do no better in endeavoring to give our readers an idea of the author's treatment and conclusions than to quote a sentence here and there from his final chapter, as follows: "All plants agree closely in their essential cell structure, the typical cell having a cellulose membrane and a single nucleus." "The lowest plants are mainly aquatic, and it is exceedingly probable that this is the primitive condition of plant life." "The peculiar group of motile green algæ, the Volvocineæ, probably represents more nearly than any existing forms the ancestral type of all the higher green plants. These ciliated algæ are also probably related to certain colorless flagellate Infusoria, which in turn may represent the starting-point for the whole group of Metazoa among animals. It is not unlikely that the separation of the two great branches of organisms, plants and animals, took place among the Flagellata." "Starting with this primitive motile unicellular organism, there have evidently arisen a number of independent lines of development resulting in very divergent types of structure." "In these lowly organisms there is no clearly marked line between vegetative and reproductive cells."

"The increasing complexity of the plant body has been accompanied by a corresponding specialization of the reproductive parts." "The origin of the Phæophyceæ, or brown algæ, from free-swimming brown flagellate organisms, is by no means unlikely, and if this be shown to be the case they must be considered as a line of development parallel with the Chlorophyceæ, rather than an off-shoot from these." "The relationship of the fungi is still an open question." "The ancestors of the higher green plants must be sought among the simple fresh-water green algæ. The genus *Coleochæte*, the most specialized of the Confervaceæ, is the form which shows the nearest analogy with the lower

Bryophytes." "In the mosses * * the persistence of the motile spermatozoid indicates the derivation of the Archegoniates from aquatic ancestors." "The Pteridophytes, also, show traces of an aquatic ancestry in the development of spermatozoids, which require water in order that they may reach the archegonium."

"Of the Spermatophytes the Gymnosperms are obviously the lowest types, *i. e.*, they show more clearly their derivation from the Pteridophytes." "The Angiosperms are preeminently the modern plant type. These have largely crowded out the other earlier types of vegetation, and at present comprise a majority of existing species." "It is among the Angiosperms that the plant body reaches its highest expression. In the keen struggle for existence among the manifold forms of plants the Angiosperms have shown themselves to be extraordinarily plastic, and have developed every possible device to enable them to survive this fierce competition."

We need quote no more from this very suggestive and very readable book. Every botanist and every earnest botanical student will read it with interest and profit.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

Die Spiele der Menschen. Von KARL GROOS. Jena. 1899.

Professor Groos follows up his work on Animal Play with his promised book on Human Play. He divides this last work into two sections, the first discussing the facts of play under headings, Touch Plays, Temperature, Hearing, Sight, Motor Plays of various kinds, and purely psychic plays; the second, discussing theories of play under headings, Physiological, Biological, Psychological, Æsthetic, Sociological and Pedagogical. The general grouping of facts is, as regards biological results, into activities which serve as exercise and those which serve as display in impressing others—that is in the two divisions, where individual significance is dominant, or social significance. Of course, this is a quite objective classification; the child not consciously taking exercise—this being really work—but continuing the activity for its immediate pleasurableness. The showing-off play is largely consciously such; there is here more of the subjective and teleological factor.

Under Hearing and Sight Plays Professor Groos is quite full and interesting, really giving in outline the evolution of these senses in the race and individual. We might ask why he divides Hearing Play into passive and active, and not other sense plays. The child is, indeed, diverted either by your singing, or by his singing to himself, but also both by your passing things before his eyes and himself passing things before his own eyes. Later he both looks at pictures in books and draws pictures for himself. Indeed, it is plain that gratification of any sense may be either active or passive, the active side leading off into art activity and art work.

Professor Groos's account of Motor Plays is hardly as full and satisfactory as that on Sense Plays. We find here, as elsewhere, too often a heaping-up of facts and of quotations with very cursory interpretation. Thus (p. 95) he rather hastily lumps the American habit of gum chewing with betel-chewing, and with the habit of chewing bits of sticks and grass, as motor plays for jaws and tongue. But while it is plain that the gum-chewer may use a piece gum as a mouth-plaything, yet to a large extent gum chewing is merely a morbid nervous habit, or a means of gratifying sense of taste, and in both these ways not play. So also the athlete who chews gum or other articles during a football game is not in this playing. Chewing is only play when it is chewing for chewing's sake, and not as a mere relief from nervous tension, or for taste pleasure or to help endurance and grit.

Professor Groos rightly regards the psychological mark of play not as imitation, but as direct pleasurableness. The mere biological activity comes first as outcome of bare physiological impulse; thus the infant grasping indefinitely feels something soft, experiences pleasure and keeps handling the object. Objectively and biologically all this activity is play, but psychologically only the later half (p. 95). As to physiology, "Es sind zwei Hauptprincipien, die eine psychologische Theorie des Spiels beherrschen müssen, das der Entladung über-

schüssiger Kräfte und das der activen Erholung erschöpfter Kräfte." The æsthetic social point of view is enlarged on throughout much in the same way as in his previous work.

In general the remarks we have made on Professor Groos's previous work (*Psychological Review*, Vol. 6, p. 86 ff.) apply also to this. The last book is larger, fuller and more cautions, but it lacks in clearness and directness and penetration. Though sometimes suggestive, it is rarely illuminating. Very comprehensive and learned, it is useful as a summary and discussion, but it has not the vitality of real research. The book is swamped in quotation, and we have more a history and discussion of opinion than a first-hand investigation. Though by bringing in everything of the least relevancy Professor Groos attains a certain completeness, it is greatly to be doubted whether in breaking ground in a new subject this is the most useful method. The foundations for a real science of play can only be laid by the direct detailed study of the life-history of the individual, the results being made to an extent verifiable by the photograph and phonograph.

Hiram M. Stanley.

BOOKS RECEIVED.

The Elements of Practical Astronomy. W. W. Campbell. New York and London, The Macmillan Company. 1899. Pp. xii + 264. $2.00.

Nature Study for Grammar Grades. Wilbur S. Jackman. New York and London, The Macmillan Company. 1899. Pp. 407. $1.00.

The Fairyland of Science. Arabella B. Buckley. New York, D. Appleton & Co. 1899. Pp. x + 252. $1.50.

Electricity in Town and Country Houses. Percy E. Scrutton. Westminster, Archibald Constable & Co. 1899. 2d Edition. Pp. xii + 148.

Report of the Commissioner of the United States Commission of Fish and Fisheries. Pp. clxxv + 350.

Corn Plants. F. L. Sargent. Boston and New York, Houghton, Mifflin & Co. 1899. Pp. 106. 75 cts.

Anglo-American Pottery. E. A. Barber. Indianapolis., Ind., Press of the Clay Worker. 1899. Pp. xix + 161.

Photographic Optics. R. S. Cole. New York, D. Van Nostrand Company. 1899. Pp. 330.

SCIENTIFIC JOURNALS AND ARTICLES.

The Botanical Gazette for April contains the following leading articles: 'A Conspectus of the Genus *Lilium*,' by F. A. Waugh, which brings together and organizes the widely scattered material; 'Some Appliances for Elementary Study of Plant Physiology,' by W. F. Ganong, in which are described, with figures, a temperature stage, a clinostat, a self-recording auxanometer, an osmometer, a respiration apparatus, a germination box, a transpiration device, the graduation of roots, tubes, etc., and a root-pressure gauge; 'Oogenesis in *Pinus Laricio*,' by Charles J. Chamberlain, a paper with plates, in which the following results are announced: The ventral canal cell occasionally develops as an egg; the chromatin of the egg nucleus takes the form of nucleoli which finally collect from all parts of the nucleus to a definite area near the center and there develop into a typical spirem; the chromatin of the two sexual nuclei is in the spirem stage at fusion; the fate of the spindle indicates that the kinoplasmic fibers arise through a transformation of the cytoplasmic reticulum; a continuation of 'The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan,' by Henry C. Cowles, the present part, profusely illustrated, discussing the encroachment on preexisting plant societies and the capture of the dune-complex by vegetation. Under 'Briefer Articles' Julia W. Snow describes (with plate) the life history of a new Ulvella (*U. Americana*), and Bradley M. Davis discusses recent work on the life history of the Rhodophyceæ. The number closes with the usual reviews, notes for students and news.

American Chemical Journal, April, 1899. 'On the Hydrolysis of Acid Amides:' By I. Remsen and E. E. Reid. The rate of hydrolysis of a large number of acid amides was compared and certain groups or positions of groups were found to exercise a marked influence on the reaction. In general the results agree with those obtained in the study of the rate of formation of ethereal salts. Ortho groups were found to exert a very marked 'protective' influence in many cases. 'Aliphatic Sulphonic Acids:' By E. P. Kohler. The author describes the preparation and reaction of (1) brome-

thylene sulphonic acid and its derivatives. 'A Serviceable Generator for Hydrogen Sulphide:' By W. P. Bradley. This generator is so arranged that all the acid is used, and it only needs filling several times a year. The iron salt formed does not mix with the acid, but is drawn off and thrown away.

J. ELLIOTT GILPIN.

SOCIETIES AND ACADEMIES.

THE NATIONAL ACADEMY OF SCIENCES.

THE annual stated meeting of the National Academy of Sciences was held at Columbian University beginning Tuesday, April 18th, and ending Thursday, April 20th. The members missed the rooms to which they were so long accustomed in the National Museum, but the growth of this institution has been so marked that there is no longer any room available for such purposes. A committee has been appointed to secure, if possible, permanent quarters, and it is hoped that, in view of the relations of the Academy to the United States government, rooms may be set aside in some public building for the use of the Academy.

The papers presented at the public sessions were as follows:

1. Ophiura Brevispina, W. K. Brooks and Caswell Grave.
2. The Shadow of a Plant, A. Hall.
3. On the Tanner Deep Sea Tow Net, A. Agassiz.
4. On the Acalephs of the East Coast of the United States, A. Agassiz and A. G. Mayer.
5. On the Limestones of Fiji, E. C. Andrews; communicated by A. Agassiz.
6. On the Bololo of Fiji and Samoa, W. McM. Woodworth; communicated by A. Agassiz.
7. On the Diamond and Gold Mines of South Africa, A. Agassiz.
8. Progress in Surveying and Protection of the U. S. Forest Reserves, Chas. D. Walcott.
9. The Resulting Differences between the Astronomic and Geodetic Latitudes and Longitudes in the Triangulation along the Thirty-ninth Parallel, H. S. Pritchett; introduced by Chas. D. Walcott.
10. The Work of the Division of Forestry, Department of Agriculture, Gifford Pinchot; introduced by Chas. D. Walcott.
11. On the Development by Selection of Supernumerary Mammæ in Sheep, A. Graham Bell.
12. On Kites with Radial Wings, A. Graham Bell.
13. Remarks on the Work of the Nautical Almanac During the Years 1877–98 in the Field of Theoretical Astronomy, S. Newcomb.
14. Exhibition of Specimens of *Nautilus pompilius*, W. K. Brooks and L. E. Griffin.

The new members elected are: Professor C. E. Beecher, Yale University; Professor George C. Comstock, University of Wisconsin; Professor Theodore W. Richards, Harvard University; Professor Edgar F. Smith, University of Pennsylvania, and Professor E. B. Wilson, Columbia University.

The Academy adjourned to meet in New York next November.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

THE 499th meeting of the Society was held at 8 p. m., April 1st, in the assembly room of the Cosmos Club. The first paper was by Mr. G. W. Littlehales on 'The Prospective Place of the Solar Azimuth Tables in the Problem of Accelerating Ocean Transit.' A brief abstract of this paper will appear later in SCIENCE. The second paper was by Mr. E. G. Fisher on 'Data Relating to Nickel Iron Alloy.' The third paper was by Mr. H. A. Hazen on 'Electric and Magnetic Weather.' Mr. Hazen said in part:

One of the earliest coincidences between the weather and magnetism was published in a set of curves in the Annual Report of the C. S. O. for 1882, showing the exact correspondence between the curves of diurnal range of magnetic declination and pressure of the air. In April, 1898, a period of 25.912 days was found from temperatures for 20 years at Omaha, Neb., and this period applied to the annual observations in the United States from 1870 to 1898 (about 400 occurrences) showed a marked maximum point on one day throughout. The largest number of auroras observed in any one day in the United States fell upon this same day (not included, however, in the count). In February, 1899, Dr. Ekholm sent a paper in which he had established a period of 25.92876 days from observations of the auroras in Sweden for 175 years. This period, applied to the above observations, gave almost a straight line. The great danger of using the twenty-four-hour change in any element was pointed out. It was shown

that there was almost an exact accordance between the diurnal range in magnetic diclination, horizontal and vertical form. When the fluctuations in these elements from day to day were compared, however, there were remarkable periods of coincidence, combined with non-coincidence. It was shown that the curves for grains in a cubic foot of air and for pressure fluctuations were exactly coincident at St. Louis, Mo. When these curves were compared with the magnetic curves there was no difficulty found in matching them with one or another of the latter. This seemed to show an intimate connection between the phenomena, and it now remains for those versed in terrestrial magnetism to explain the want of coincidence in the phenomena.

E. D. Preston,
Secretary.

GEOLOGICAL SOCIETY OF WASHINGTON.

At the regular meeting of this Society, held in Washington, D. C., on April 12, 1899, Mr. Alfred H. Brooks communicated some 'Notes on the Geology of the Tanana and White River Basins, Alaska.'

The region embraces the Lower White and the major part of the Tanana River, both tributary to the Yukon. To the south the area is bounded by a part of the St. Elias range, by the Natzutin Mountains and by the Alaskan range, and lies chiefly in the region of the dissected Yukon plateau.

A complex of gneisses, gneissoid and massive granites, with some dioritic rocks, are believed to be the basal series. They are succeeded by metamorphic rocks which have been differentiated into three groups. These are unconformably overlaid by the Wellesley formation, consisting chiefly of conglomerate, of Devonian or Carboniferous age. On the Lower Tanana some sandstone and slate beds were noted and called the Nilkoka beds, and these are probably also Paleozoic. These have all suffered considerable deformation and often carry mineralized quartz veins. In the older and more altered rocks the quartz is more plentiful than in the younger beds. Assays of a number of samples gave traces of both gold and silver. A small area of very slightly deformed soft yellow sandstone was tentatively classed as Eocene. The position of two systems of structure lines goes to show that the deformation of the region was caused by two synchronous thrusts coming from different directions, and these were probably lines of movement during several periods of deformation.

The summits of the old plateau remnants are a striking feature of the region and mark an old peneplain. During the late Tertiary time this peneplain was elevated and probably somewhat deformed and was then deeply dissected. The evidence goes to show that the drainage of the upper Tanana and middle White then flowed southeast and probably found its way to Lynn Canal by way of the valleys of the Nissiling, upper Alsek and Chilkat Rivers. A depression succeeded the uplift, and the partially drowned valleys were then filled with sediments. Toward the close of this period of depression the White River Valley was occupied by ice, and probably a little later glaciers moved down some of the southern tributaries of the Tanana. No evidence of general glaciation was found in the region. The last orographic disturbance was the elevation of the land mass to about its present position, and this caused a partial dissection and terracing of the sediment of the older valleys.

Mr. J. S. Diller exhibited specimens of *Paleotrochis* which had been described in 1856 by E. Emmons as siliceous corals and regarded as the oldest fosssils known. Professor James Hall regarded them as concretions. Professor J. A. Holmes, of North Carolina, examined the rock in the field and considered it of igneous origin, while Mr. C. H. White, who examined the specimens collected by Holmes, pronounced the forms organic. Nitze and Hanna, of the Geological Survey of North Carolina, maintain the igneous characters of the rock, and this view is strongly supported by Mr. Diller, who showed that the supposed fossils and concretions are spherulites in a more or less altered rhyolite. Mr. Diller's paper will be published in full in the *American Journal of Science.*

W. F. Morsell.
U. S. Geological Survey.

CHEMICAL SOCIETY OF WASHINGTON.

The regular meeting was held on March 9, 1899.

The first paper of the evening was read by Dr. F. K. Cameron and was entitled 'Acetone-Chloroform, 2d paper,' by F. K. Cameron and L. J. Briggs.

The second paper was read by Mr. T. H. Means and was entitled 'Estimation of the Salt Contents of Soil Waters,' by T. H. Means and F. K. Cameron. This method has been devised for a rapid estimation of the relative proportions of chloride, sulfates and carbonates in the 'alkali' soils of the Western districts. It is used as a check upon the electrical method for the determination of the soluble salt content of soils, as well as to furnish approximate analyses in the field without waiting for complete analyses to be made in the laboratory. The method determines chlorides, sulfates and carbonates in terms of the sodium salt. A sample of water is taken. or an extract is made of the soil, and the solution filtered or decanted. The solution need not be clear. An excess of barium nitrate (10 cc.) is added to 10 cc. of the soil extract, thus precipitating sulfates and carbonates. The excess of barium nitrate is titrated back with potassium chromate, using silver nitrate on a porcelain plate as an indicator. In the same vessel silver nitrate is added, using potassium chromate on the plate as an indicator, thus precipitating the chloride. A few drops of nitric acid are now added and the liquid heated, driving off the carbon dioxide from the barium carbonate. The excess of nitric acid is neutralized by powdered magnesium carbonate. Again the solution is titrated with potassium chromate, the quantity required giving the amount of carbonates. This subtracted from the sum of the sulfates and carbonates, as found above, gives the sulfates. This method makes the three titrations in one vessel, the apparatus being of such a simple nature that all can be carried in a camping outfit.

The third paper was read by Mr. J. K. Haywood and was entitled 'The Determination of Calcium and Magnesium in Ashes.' The author has found that in determining calcium and magnesium it is not essential to wash the voluminous ppt. of basic acetate of iron and phosphate of iron, but that results of almost equal accuracy are obtained by making the precipitation in a 500-cc. flask, filling up to the mark, passing through a dry filter and using aliquot portions of the filtrate for analysis. The above is substantiated by experimental data.

The last paper was read by Dr. H. C. Bolton and was entitled 'The Classification of Chemistry Proposed by the International Catalogue Committee of the Royal Society, a Critical Analysis,' by W. P. Cutter and H. C. Bolton. The paper analyzed the proposed scheme of classification of chemical titles drawn up by the Committee on the International Catalogue of the Royal Society. It characterized the system as conglomerate, since numbers, Roman capitals, lower case, italic letters and Greek letters are mixed up with alphabetical headings. The system embraces also methods of notation which are very objectionable, inasmuch as the symbols are analogous in structure and appearance to chemical formulæ, yet they are essentially different. The scheme proposed, if intended to facilitate research, is pronounced by the authors of the analysis an almost total failure.

WM. H. KRUG,
Secretary.

THE MINNESOTA ACADEMY OF NATURAL SCIENCES.

AT the regular monthly meeting of April 4th three papers of general interest were presented. Dr. F. W. Sardeson discussed the primitive structure of the Crinoid stem. Specimens were exhibited showing the manner of development from the first Cystidean type of structure, *i. e.*, an elongation of the body wall supported by hexagonal plates; the arrangement into five vertical rows of the alternating transversely elongated six sided plates; the arrangement of these plates in transverse circles forming distinct sections and joints, this being the most primitive structure of the stem seen in the Crinoidea; the circle of five plates in each section united in such manner as to form a solid ring with a central pentagonal perforation or canal.

Dr. U. S. Grant described a driftless area in northeastern Minnesota. The area in question is a small one, 8 by 12 miles, around Wilder Lake, entirely free from the drift which covers the country around it so deeply. The rock

surface is decayed as if no removal or grinding of the surface material had taken place by glacial action, and is entirely free from drift boulders. As a probable explanation the author suggested that this area lay to leeward of a great ice ridge which effectually shielded it from the direct action of the glacial ice stream.

Mr. H. B. Humphrey detailed his observations upon the influence of low temperatures upon plants, and described the difference of effect of sudden changes and gradual lowering of the temperature. Living specimens kept for a month or more in commercial cold-storage rooms at a point slightly below freezing exhibited phenomena of starvation.

CHARLES P. BERKEY,
Corresponding Secretary.

MINNEAPOLIS, MINN.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

AT the meeting of the Academy of Science of St. Louis of April 3d a paper by Mr. Stuart Weller, entitled 'Kinderhook Faunal Studies, I: The Fauna of the Vermicular Sandstone at Northview, Webster county, Mo.,' was presented for publication; and Mr. Trelease exhibited a plaster cast of a gigantic monstrosity of *Cereus marginatus*, known as the Rosa de Organo, presented to the Missouri Botanical Garden by Professor Frederick Starr, and reported that this formation was locally abundant at points south from Aguas Calientes. The speaker exhibited a large number of comparable cactus monstrosities from the plant-houses of the Missouri Botanical Garden and the collection of the President of the Cactus Association of St. Louis, and a similar deformity of one of the cactus-like Euphorbias of the African region, commenting on this teratological type. It was shown that for the purposes of gardeners, for whom these unusual forms appear to possess a considerable interest, they are commonly divided into two types, in one of which, commonly designated by the varietal name cristata or cristatus, the monstrosity takes the form of a fan or a contorted ridge, while in the other, commonly designated by the varietal name monstrosa or monstrosus, it consists of irregular bunching of the branches and an interruption of the customary longitudinal ridges of such a genus as *Cereus*.

WILLIAM TRELEASE,
Recording Secretary.

BOSTON SOCIETY OF NATURAL HISTORY.

A GENERAL meeting was held March 15th; twenty-eight persons present.

Mr. E. C. Jeffrey, in an account of the genus *Equisetum*, stated briefly the sexual and asexual methods of development. The internal structure of the stem was described, and the relationships of the Equisetæ to the Lycopods and ferns were noted. Structurally Archæocalamites resembles the higher Lycopods. The branches of Calamites originate from the center of the ring of nodal wood or from its lower border. Casts of Calamites show pith.

Dr. C. R. Eastman read a paper on some new North American fossil fishes. An abstract will appear in an early number of SCIENCE.

SAMUEL HENSHAW,
Secretary.

DISCUSSION AND CORRESPONDENCE.

ON THE ACTION OF THE COHERER.

EXPERIMENTS have been made at the physical laboratory of the Missouri State University which show that the action of the Branly tube is due to an actual cohering of the particles. The action consists, first, in an electrostatic attraction causing the particles to come in contact, and second, in a fusion of the points of contact.

An instrument has been designed and constructed which clearly shows this coherence and renders its study possible. It consists of two electrodes, one a metallic plate on which the filings are placed, and the other a metallic point carried on a pivoted arm swinging in a vertical plane. If a considerable difference of potential is maintained between these electrodes, and the point be brought in contact with the filings and then carefully lifted, a thread will attach itself to the point and may be drawn out to two or more inches in length. The difference of potential has, in our experiments, been produced in a variety of ways. Thus the instrument was placed in circuit with two dry cells and a 160-ohm relay, and threads

produced. Here the effect was caused, not by the low potential of the battery current, but by the much higher potential of the extra current produced by the constant breaks at the lower end of the thread. This was demonstrated by placing a non-inductive resistance of about 1,000 ohms in parallel with the coherer. This entirely prevented the action. Attaching the ends of the secondary of an induction coil to the coherer gave similar results, as did also the Holtz machine.

But these threads remained cohering after there had ceased to be a difference of potential between the electrodes. In a vacuum the threads still remained hanging, showing that the friction and pressure of the air did not maintain the coherence. Under the microscope the points of contact appear to be fused, and other observers have noticed bright points after coherence is destroyed. That fusion occurs is also shown by the fact that metals having a high melting point give threads of much less tenacity than those with low melting points. Thus platinum and iron give very fragile threads, while tin, lead and aluminum give threads capable of enduring considerable flexure.

With the Holtz machine threads could be produced only when the machine was run slowly. If it was run too fast the particles would fly back and forth between the electrodes of the coherer. The point of the coherer, becoming charged, induces a charge in the particle nearest to it. This causes an electrostatic attraction, the particle flies to the point and, receiving a like charge, is at once repelled. But the instant it comes in contact the points of contact fuse, and if the charge on the electrode be small this fusion will be sufficient to resist the tendency to fly off and the filing will remain, becoming a part of the electrode and repeating the action on the next particle. Thus consecutive filings are united and a continuous thread of filings fused together, which connects the electrodes, reducing the resistance greatly. In a Hertzian field the action is precisely similar, the difference of potential here being produced by the action of the Hertz waves. Short threads of filings were obtained, as in the preceding experiments.

These experiments show that the great reduction in the resistance of the tube is due to the formation of continuous threads of metal connecting the electrodes. They also indicate some of the points which a good coherer must possess. The filings used should be composed of metal not easily oxidized, of small specific gravity and low melting point. The electrodes should consist of points or roughened surfaces of similar metal. Further, it is difficult to decohere a thread while a current is flowing, since the induced current at any break tends to bring back the parts to coherence. Marconi avoids this action by the use of a high resistance in parallel with the coherer. The necessity for this resistance can be avoided by having the current through the coherer broken before the tapping occurs. Experiments are being continued in the direction of a practical application of these principles.

M. H. LOCKWOOD,
E. B. WHEELER.

MARCH 30, 1899.

TWO-HEADED SNAKES.

TO THE EDITOR OF SCIENCE: I am engaged in the study and description of two-headed snakes by means of skiagraphy. Although I have in hand eight specimens from various museums, I have been unable to locate the Tropidonotus from the Massachusetts State Collection, described by Wyman in the *Proc. Bost. Soc. Nat. Hist.*, Vol. IX., p. 193, and the three snakes described by Mitchell in the *Amer. Jour. of Science*, Vol. X., p. 48.

I write in the hope that one of your readers may be able to help me in my quest of these four specimens, and that I may be informed of any other snakes with this abnormality in American collections, in order that I may make note of, or describe, them in my forthcoming paper.

ROSWELL H. JOHNSON.
1727 CAMBRIDGE STREET, CAMBRIDGE, MASS.,
April 14, 1899.

DUPLICATION OF GEOLOGIC FORMATION NAMES.

IT was not my intention, in my letter in SCIENCE of March 31st, to discuss the question as to whether certain names of geologic formations conflicted, or to discuss the undesirability of

using names that have more or less similarity. Its purpose, as stated, was 'to illustrate what the present system is leading to.' Names of formations and dates of publication were given for this purpose.

However, Director G. M. Dawson, in his recent communication in SCIENCE, states that it is not apparent from my remarks that Cache Creek group of formation holds priority. I do not see how any other construction can be given to the third paragraph of my letter. It is there briefly shown that Dr. Selwyn described the Upper and Lower Cache Creek group in 1872, and that in 1896 Dawson applied the name Cache Creek formation to both series. It is further evident, from the names and dates given, that the Cache Creek group has priority over either Cache Valley group or Cache Lake beds.

F. B. WEEKS.

U. S. GEOLOGICAL SURVEY,
WASHINGTON, D. C.

NOTES ON INORGANIC CHEMISTRY.

AT the meeting of the Chemical Society (London) on March 16th Professor Dewar presented a paper on the boiling point of hydrogen, which is printed in the *Proceedings*. In obtaining liquid hydrogen great difficulty is experienced owing to the presence of small traces of air. Quantities amounting to only one thousandth of one per cent. accumulate in the solid state and eventually choke the nozzle of the apparatus, necessitating the abandonment of the operation. Dewar obtained 250 cubic centimeters of colorless liquid hydrogen and used this for the determination of the boiling point. His previous observations, using a platinum resistance thermometer, gave the boiling point as —238°. In these latest experiments a possible constant error in the use of the platinum thermometers was checked by using a rhodium-platinum resistance thermometer, the alloy containing ten per cent. rhodium. Examination had shown that alloys, unlike pure metals, showed no sign of becoming perfect conductors at absolute zero. The rhodium-platinum thermometer gave the boiling point of hydrogen as —246°, and this the author considers to be more accurate than the previous determinations, especially as it agrees very fairly with the boiling point calculated from the results of Wröblewski and of Olszewski.

IN an addendum dated March 17th Dewar gives the first results from a constant-volume hydrogen thermometer working under diminished pressure. This gave —252° as the boiling point of hydrogen. The three results in absolute temperature are: (1) platinum resistance thermometer, 35°; (2) rhodium-platinum resistance thermometer, 27°; (3) hydrogen thermometer, 21°. From this Dewar states that it appears that the boiling point of hydrogen is really lower than was anticipated.

IN the *Journal of the Society of Chemical Industry* the use of titanium compounds in the dyeing industry is discussed, and it is shown that in many cases they may be successfully utilized. Especially are they valuable as mordants for alizarin yellows and oranges, and for basic dyestuffs. The tannate is not unstable towards acids and little influenced by light, and according to the author is valuable as a water-color. As experiments progress it is by no means impossible that many of the elements which now have little or no practical value may find uses, and work along this line offers much prospect of success.

IN the last number of the *Zeitschrift für anorganische Chemie*, Piccini publishes the full details of the preparation of cesium manganese alum and a complete description of the salt. This is of more than passing interest from the fact that it is the first salt of trivalent manganese whose constitution is not open to question. Manganese alums are described in older chemical literature, but efforts to repeat their preparation have not been successful. By utilizing the electric current to oxidize manganese sulfate, Piccini forms the alum without difficulty, and in crystals large enough for a complete crystallographic study. It is thus settled that in manganic compounds the manganese is trivalent, and hence allied to aluminum, chromium and iron. From a private communication I learn that other manganese alums have been prepared and studied by Professor Christensen, and will shortly be described.

J. L. H.

CURRENT NOTES ON METEOROLOGY.

FROST PREDICTION AND PROTECTION.

BULLETIN No. 23 of the Weather Bureau is entitled *Frost: When to Expect it and How to Lessen the Injury Therefrom*, and is by Professor W. H. Hammon, Local Forecast Official at San Francisco. This paper is a revision of one prepared three years ago, and is the result of careful study extending over a long period. The *Bulletin* classifies the different methods of frost protection under five heads. Of these the most important ones are as follows: I., diminishing radiation; II., raising the dew point of the air, and, III., increasing the temperature of the air. Under the first class come screens of various kinds, such as glass, cloth or laths; and the well-known 'smudges.' The raising of the dew point is accomplished by burning damp 'smudges;' by evaporation from water tanks heated by fires; by spraying and by irrigating at times of frost, etc. The heating of the air by means of small fires, scattered about through the orchard or over the field, has also been found a very effective protector against frost in the drier parts of California. Among the various ingenious devices cited by Professor Hammon, the following is worthy of note. The machine, designed by Mr. George F. Ditzler, of Biggs, Cal., consists of a large, deep, sheet-iron tank, three or four feet square, mounted on a truck. About six inches from the bottom of the tank a wire grate is erected. Through a hole in the bottom of the tank, beneath the screen, a blast of air is admitted, which is produced by a revolving fan, operated by a sprocket chain and wheel attached to the wheel of the truck. A water cask and force pump, operated by the movement of the wagon, complete the outfit. A little tar or other fuel is placed upon the grate and ignited, and the tank is filled with wet straw or manure. When the machine is put in motion the blast produced by the fan causes an intense fire. All the heat of the fire has to pass through three feet of wet straw before it can reach the air. Thus evaporation is very active, and the vapor, rising from the wet material, immediately condenses, forming a dense fog or mist. While the machine is in motion, being driven forward and back between the rows of trees in the orchard, water is continually pumped from the cask and discharged from small holes about the top of the tank upon the fuel. One such machine is said to evaporate 100 gallons of water an hour. The fog thus formed is stated to be so dense that the driver has frequently to go ahead and lead the horses.

A FOG DISPELLER.

WHILE the *production* of fog, as a means of protection against frost, is an extremely desirable thing in some districts on land, the possibility of *dispelling* fog over the oceans is another matter which is no less anxiously sought for. The following account of the so-called *Tugrin Fog Dispeller* is found in the *Monthly Weather Review* for January. The apparatus consists of an outlook pipe, eight feet long and three inches inside diameter, with a wide flange at the mouth, placed so as to be convenient to the navigating officer. A tube enters the pipe from below, and a blower sends a powerful stream of warm air through the tube and the pipe straight ahead, blowing a hole right through the fog, which is rolled back in every direction. It is said that the navigating officer is thus enabled to see through the densest fog for several hundred feet.

NOTES.

THE report of the Meteorological Council to the Royal Society for the year ending March 31, 1898, shows that of the 8:30 p. m. forecasts issued daily the percentage of verification was 81. Fifty-five per cent. of these forecasts were fully verified, and 26 per cent. were partly verified. The highest percentage of verification attained during the decade 1888–1897 was 84, in 1893. Of the storm warnings issued during the past year, 91.8 per cent. were justified by subsequent gales or strong winds.

THE progress of the investigation of the free air by means of kites continues. From the *Monthly Weather Review* for January it is learned that a kite corps has been formed at Bayonne, N. J., and that nearly 40 ascents were made between April and December of last year. The altitudes reached were in most cases not above 500 feet, and observations of temperature only were made.

R. DEC. WARD.
HARVARD UNIVERSITY.

SCIENTIFIC NOTES AND NEWS.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE spring meeting of the Council of the American Association for the Advancement of Science was held April 18, in Washington, D. C.

The Permanent Secretary, Dr. L. O. Howard, presented for the information of the Council an account of the operations of his office since the last Council meeting. He also presented his financial statement for the last half of the year 1898, which was approved and ordered to be printed. He announced that a contract had been signed which provided for the printing of the Volume of the Proceedings of the Association for 1899 by the Chemical Publishing Company of Easton, Pa.

A number of matters relating to the Columbus meeting the coming August were discussed. The Council expressed its preference in favor of Saturday, August 26th, as the day upon which the all-day excursion should be given, and further, in order that the scientific sessions should not be interrupted, passed a resolution expressing its desire that afternoon excursions and other social functions should not be arranged by the Local Committee to begin before 4 o'clock in the afternoon. It was decided to hold the final public meeting of the Association on Friday night and the meeting of the Nominating Committee on Thursday night. Inasmuch as some dissatisfaction had been expressed with the plan adopted at the Boston meeting of doing away with the general morning sessions, it was decided to resume these daily sessions at 10 o'clock each morning, confining the business, however, to a consideration of matters emanating from the Council and limiting their duration to half an hour.

The Permanent Secretary was authorized to invite Mr. Elihu Thomson to deliver the public lecture at the Columbus meeting.

The Chairman of the Committee on Association Badge reported progress and submitted designs.

An application from Professor C. B. Davenport, of the Museum of Comparative Zoology, Cambridge, Mass., for an appropriation from the Research Fund of $50 to enable Mr. Charles C. Adams to visit the headwaters of the Tennessee River to collect shells for the genus *Io* for the purpose of a specific study of variation was referred to the Committee on Grants, with power to act.

GEOLOGICAL SURVEY WORK IN ALASKA.

THE Secretary of the Interior has approved plans submitted by Director Walcott, of the Geological Survey, for the continuation of surveys in Alaska during the summer of 1899. It is proposed that one party, to consist of Mr. W. J. Peters, topographer in charge, and Mr. Alfred H. Brooks, assistant geologist, and equipped with pack animals and outfit, shall proceed from Chilkat Inlet, along the northern side of St. Elias Range, to the head of White River, and conduct such explorations as may be feasible to locate the sources of the Copper, Tanana and Nabesna Rivers. Between the Tanana and the Yukon there is a range of mountains composed largely of the gold-bearing schists. Although quite extensively prospected, but little is known of this range. The explorations will be by the most feasible route to Eagle City and thence westward within the area between the Tanana and the Yukon. It is expected that the party will reach a point on the Yukon in September, and return by the way of St. Michael or, if more advantageous, by way of Dawson.

The second party, consisting of Mr. F. C. Schrader, assistant geologist, and a topographer, will proceed down the Yukon to Fort Yukon, and from there carry forward explorations northward toward the Koyukuk. The object of this party is to explore the principal waters of the Koyukuk within the Arctic Circle. As the region is almost unknown, the special route to be traversed will be left to the discretion of the head of the party. The equipment of the party is to consist of canoes of the same type as those used in the explorations during the field season of 1898. It is expected that the party will return down the Koyukuk to the Yukon and out by the way of St. Michael.

The plans have been developed as a result of thorough discussion by the members of the Survey familiar with explorations in Alaska and the resources of the Territory.

W. F. M.

SCIENTIFIC POSITIONS UNDER THE GOVERNMENT.

A CIVIL service examination will be held on May 9th to establish an eligible register for the position of Expert in Terrestrial Magnetism, U. S. Coast and Geodetic Survey, Department of the Treasury, at a salary of $2,500. The examination will consist of the subjects mentioned below, which will be weighted as follows: (1) experience in conducting magnetic surveys, including a knowledge of the literature, past and present, of the subject, 30; (2) original investigations and training connected with the study of magnetism, 40; (3) practical questions relative to terrestrial magnetism, 30.

An examination will be held in June for the position of Inspector of Standards, Office Standard Weights and Measures, U. S. Coast and Geodetic Survey, Department of the Treasury, at a salary of $3,000 per annum. Competitors will not be required to be present at an examination, but a decision will be made on the result of the following tests: (1) training and experience, comprising, especially, original investigations in physics, 30; (2) published papers having special reference to investigations in physics or pertaining to standards of weight and measure, 30; (3) thesis of not less than two thousand (2,000) nor more than four thousand (4,000) words, on the proper functions of a national office of weights and measures, 40.

On May 16th an examination will be held for the position of Field Assistant, Division of Forestry, Department of Agriculture, with a salary of $1,000 a year. The subjects and weights are as follows: (1) Forestry, 60; (2) Botany, 10; (3) English (essay), 10; (4) Education and Experience, 20.

In view of the scarcity of applicants the examination scheduled to be held on April 11–12, 1899, for Examiner of Surveys, General Land Office, Department of the Interior, has been postponed to May 9–10, 1899. The examination is chiefly on land surveying and the salary is $5 per day.

GENERAL.

THE National Academy of Sciences at its meeting last week elected the following new members: Charles E. Beecher, professor of historical geology at Yale University; George C. Comstock, professor of astronomy in the University of Wisconsin; Theodore W. Richards, professor of chemistry in Harvard University; Edgar F. Smith, professor of chemistry in the University of Pennsylvania, and E. B. Wilson, professor of zoology in Columbia University.

DR. DAVID GILL, of the Royal Observatory, Cape of Good Hope, has been awarded the Watson medal of the National Academy of Sciences.

MR. I. H. BURKILL has been appointed assistant to the Director of Kew Gardens.

DR. CHARLOTTE ANGUS SCOTT, professor of mathematics at Bryn Mawr College, has been elected an honorary member of the Amsterdam Mathematical Society.

MR. G. L. TELLER, whose recent work on the Chemistry of Wheat at the Arkansas Agricultural Experiment Station has attracted attention, has resigned his position as chemist of that Station for the purpose of taking charge of chemical work in the Chidlow Institute of Milling and Baking Technology, Chicago. This Institute, recently founded by Mr. David Chidlow, who has been for some time past chemist to the Pillsbury-Washburn Flour Mills Co., of Minneapolis, is the only institution in America which offers the advantages of technical instruction to millers and bakers.

DR. HEINRICH KIEPERT, since 1859 professor of geography in the University of Berlin, well known for his explorations in Asia Minor and important publications, died on April 21st in his 80th year.

CHARLES H. SWAN, a well-known civil and and sanitary engineer, died in Roxbury, Mass., on April 17th.

MR. SPENCER H. DEVARRE, formerly instructor in mathematics in Yale University, has died at Brooklyn.

WE learn from *Nature* that the Easter dredging expedition of the Liverpool Marine Biology Committee was brought to an untimely end by an unfortunate boat accident in Port Erin Bay. On March 31st dredging and trawling were carried on from the fisheries steamer *John Fell*, and on the following forenoon the Tanner closing net and the method of pumping plankton

from the bottom by means of a hose-pipe were tried on the steamer. On the afternoon of Saturday, April 1st, two of the workers in the Biological Station went out to collect surface plankton in a small boat. While hauling in the tow-net when returning, the boat capsized, and both were thrown into the water. One of them (Mr. E. J. W. Harvey, of Liverpool) was picked up by another boat from the Biological Station, but his companion (Mr. Eric T. Townsend, of Manchester) was unfortunately drowned before assistance could reach him. The body was eventually recovered. Mr. Townsend was a student at the Owens College, and was occupying the College work-table at the Port Erin Biological Station.

Dr. L. Buscalioni is making collections in Brazil for the Botanical Museum at Rome.

The French government is sending an expedition to the Congo to make a topographical survey of the colony.

M. Adrien de Gerlach, the chief of the Belgian Antarctic expedition, will return with the *Belgica* without further explorations after repairs have been made at Buenos Ayres. M. Artowski, the naturalist of the expedition is already on his way home. Lieutenant Danco, who had charge of the magnetic observations, died in June, 1898.

A Russo-Swedish scientific expedition will start for the Spitzbergen Archipelago in May. The Russians will be represented by Staff Captain Sergiebsky, the zoologist Vinitsky, Dr. Bunge and the geologist and mining engineer Chernysheff. They will go in the Libau ice-breaker No. 2, and the Bakan, and join the Swedish party at Stockholm. The expedition intends to winter in Spitzbergen, the Russians at Edge Island and the Swedes at Parry Island.

As we have already stated, the next annual meeting of the British Association will be held at Dover under the presidency of Professor Michael Foster, commencing on Wednesday, September 13th. For the benefit of Americans who may propose attending the meeting, it may be added that notice of papers proposed to be read should be sent before July 1st to the Assistant General Secretary, Mr. G. Griffith, at the office of the Association, Burlington House, London.

An electrical exposition will be held in Madison Square Garden, New York, during the month of May.

The King of the Belgians, as Sovereign of the Congo Free State, has contributed £200 toward the establishment of the London School of Tropical Medicine, and the Secretary of State for India has subscribed £1,000. The Archbishop of Canterbury has also contributed £50 to the same object. Lord Lister, President of the Royal Society, was the principal guest on the occasion of the inaugural dinner in connection with the Liverpool School for the Study of Tropical Diseases on the 22d inst. A sum of £1,700 has been promised towards the expenses of the Liverpool School.

The Kansas State Legislature has appropriated $25,000 for a dairy building at the Agricultural Experiment Station and $6,000 for its equipment. The Oklahoma Legislature has appropriated $30,000 for buildings and equipment for its Agricultural Station.

It is said that the estate left by the late Baroness de Hirsch has been valued at $125,000,000, of which $100,000,000 will be expended in carrying out the various charities founded or fostered by the Baron and Baroness. The Hirsch Foundation in New York City receives $1,200,000.

Mr. Andrew Carnegie has increased his donation for the Washington Free Library from $250,000 to $300,000, in order that the building may be of more artistic construction.

We learn from *The Auk* that the Philadelphia Academy of Natural Sciences has acquired the collection of bird skins made by Mr. Joseph Hoopes, of West Chester, Pa. It contains more than 7,000 specimens, nearly all being North American land birds.

The following are the lecture arrangements after Easter at the Royal Institution: Professor J. Cossar Ewart, three lectures on zebras and zebra hybrids; Professor Silvanus P. Thompson, two lectures on electric eddy-currents (the Tyndall Lectures); Professor W. J. Sollas, three lectures on geology; Professor

Dewar, three lectures on the atmosphere; Mr. Lewis F. Day, three lectures on embroidery; Professor L. C. Miall, two lectures on water weeds; Mr. Louis Dyer, three lectures on Machiavelli; Mr. W. L. Brown, two lectures on 'To Iceland in Search of Health;' Mr. Edgar F. Jacques, three lectures on 'The Music of India and the East, and its Influence on the Music of Europe' (with musical illustrations). The Friday evening meetings will be resumed on April 14th, when a discourse will be delivered by Professor A. W. Rücker on 'Earth Currents and Electric Traction.' Succeeding discourses will probably be given by Dr. F. W. Mott, Professor C. A. Carus Wilson, Dr. W. J. Russell, Professor T. Preston, the Bishop of Bristol, Sir William Martin Conway, Mr. H. G. Wells and others.

THE Belgian Royal Academy, according to *Nature*, proposes the following subjects for essays in competition for gold medals of value 600 francs each, to be awarded in 1900. The essays are to be sent to the Secretary before August 1, 1900, each bearing a motto, and written in French or Flemish. Contrary to the usual custom, five subjects instead of three have been selected in each of the two departments of mathematical and physical science and of natural science. The mathematical and physical questions refer to: (1) critical phenomena in physics; (2) viscosity of liquids; (3) the carbon derivatives of an element whose combinations are little known; (4) the history and theory of variation of latitude; (5) the algebra and geometry of n-linear forms were $n > 3$. The questions in natural science refer to: (1) the geological formations at Comblain au Pont, and whether these are Devonian or Carboniferous; (2) the physical modifications produced in minerals by pressure; (3) the organization and development of the platoda; (4) the presence of a nucleus in the Sehizophyta; (5) the Devonian flora of Belgium.

UNIVERSITY AND EDUCATIONAL NEWS.

ASSISTANTS IN PHYSIOLOGY IN HARVARD MEDICAL SCHOOL.

Two of the four positions offered by the Harvard Medical School to properly qualified men desirious of training in physiological research and in the management of large laboratory classes in experimental physiology are not yet filled for the next collegiate year. Holders of these positions give more than half the day to research. The remaining time is spent during the first four months in learning laboratory methods and during the last four months in directing the laboratory work of the medical students, two hundred of whom work from two to three hours daily for sixteen weeks in experimental physiology. The fundamental experiments in physiology done by two hundred men working at one time present every variety of results and impart a training in observation and administration not to be acquired in other ways.

Much too may be learned by association; from six to ten men are constantly engaged in research in the laboratory of physiology, and in the departments of anatomy, histology, pathology, physiology and physiological chemistry, all of which have their laboratories in the medical school building, are more than thirty instructors. No charge of any kind is made, either for the training in physiological research and in teaching or for the use of animals and other material. Four of the eight investigations already made by holders of these positions have appeared in the *American Journal of Physiology*, and the others will be published shortly.

In addition to these opportunities the school gives each assistant four hundred dollars for superintending the class work in experimental physiology three hours daily during sixteen weeks.

Applications for these positions should be made to Dr. H. P. Bowditch, Harvard Medical School, 688 Boylston Street, Boston, Mass.

GENERAL.

THE following gifts and bequests to educational institutions have been made since our last issue: $50,000 to Oberlin College for a chemical laboratory; $8,000 to Vassar College by the will of Mrs. Luther Elthing for the founding of a scholarship; $6,000 from Miss Emily H. Bourne for the establishment of scholarships in Barnard College; $10,000 to the Catholic University of Washington by the will of Miss Mary Moran, and a conditional gift of

$30,000 to Yankton College, S. D., from D. K. Pearson.

FOREIGN journals report that the late W. J. Astrakoff has bequeathed to the University of Moscow a sum of a million roubles, on condition that it shall be expended upon the foundation of a 'Moscow University for Women,' with three faculties—mathematics, medicine and natural science. He requires that it shall be placed under the direct administration of the Ministry of Public Education and the program correspond exactly with that of the University for men.

THE Mechanical Hall of the University of West Virginia was destroyed by fire on March 4th. The building was insured for $28,000, and the loss beyond this sum is not great. The building will be immediately replaced.

THE present state of affairs in the Russian universities in extremely serious. Not only has the University at St. Petersburg been closed for some time, but similar conditions exist at Moscow, Kieff, Kharkoff, Odessa, Kasan, Tomsk and Warsaw, and in most of the technical institutes. More than 30,000 young men who will soon form an important part of the intellectual class in Russia are affected. The troubles began by a demonstration against the Rector of the University of St. Petersburg, which was followed by an encounter with the police in which Cossack whips were used upon the students. The Russian government appears to sympathize to a certain extent with the students, and an investigation has been ordered.

THE statement in the daily press to the effect that Dr. J. L. Wortmann has been elected by the Yale corporation professor of paleontology and Curator of the Peabody Museum is incorrect. It is, however, probable that the work in paleontology will be in some way divided between Professor C. E. Beecher, of Yale University, and Dr. J. L. Wortmann.

MR. J. ARTHUR THOMPSON has been appointed professor of natural history in the University of Aberdeen in succession to the late Professor Nicholson.

DR. ROBERT MUIR has been elected to the vacant professorship of pathology in the University of Glasgow. Dr. Muir was last year called from a lectureship at Edinburgh to the professorship of pathology at St. Andrews. He has published important contributions especially on the pathology of the blood and of the bone-marrow.

MR. W. A. MURRILL has been appointed Assistant Cryptogamic Botanist of the Cornell University Experiment Station for one year, during the absence, in Europe, of Dr. B. M. Duggar. Mr. Murrill is a graduate of the Washington and Lee University, and of the Virginia Agricultural College. He entered upon graduate study at Cornell University two years ago, when he was appointed scholar in botany. During the last year he held one of the positions of graduate assistant in botany at Cornell. He is still continuing graduate work.

EDGAR BUCKINGHAM, associate in physics and physical chemistry in Bryn Mawr College, has resigned his position.

J. H. MCCRACKEN, assistant professor of philosophy in New York University, has been elected President of Westminster College.

TWENTY-SIX fellowships have been announced in the University of Pennsylvania, of which the following were given in the sciences: Reappointments—*Philosophy*, H. B. Alexander; *Mathematics*, R. H. Vivian. New appointments—*Mathematics* and *Astronomy*, U. S. Hanna; *Physics*, H. S. Conrad; *Chemistry*, T. M. Taylor, M. B. MacDonald; *Zoology*, J. R. Murlin, C. B. Thompson; *Pedagogy*, I. B. McNeal.

DR. DANIEL E. ROSA, of Turin, has been appointed associate professor of comparative anatomy in the University at Sassari; Professor Bergen, of Munich, has been made professor of geology and mineralogy in the School of Mining at Klausthal. Dr. Solomon, docent in mineralogy at the University of Heidelberg, has been promoted to an assistant professorship. Dr. W. Wien, associate professor of physics at the Institute of Technology at Aix, has been called to a full professorship at the University at Giessen. Dr. Eggeling has qualified as docent in comparative anatomy and embryology in the University at Strassburg, and Dr. Zermelo as docent in mathematics and theoretical physics in the University at Giessen.